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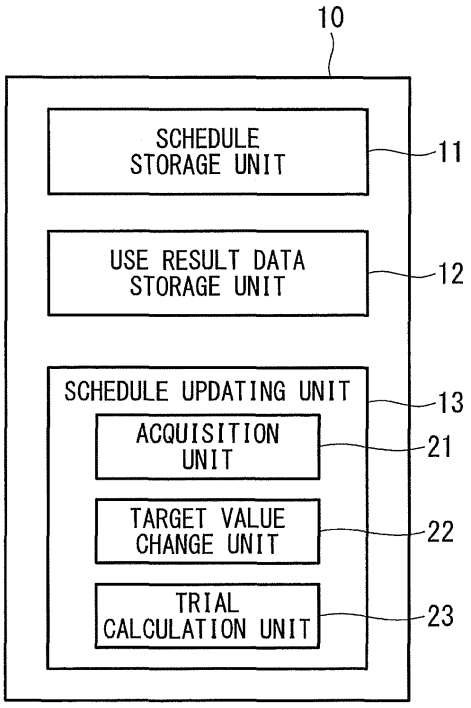
(54) HEAT PUMP WATER HEATER AND METHOD FOR CONTROLLING THE SAME

(57) In a case where a stored hot water temperature target value and a stored hot water amount target value for a next day and afterwards are changed depending on use result data, if it is determined that a minimum heat storage amount is excessive from the use result data, the stored hot water temperature target value is decreased with priority, and if the stored hot water temperature target value reaches a lower limit value, the stored hot water amount target value is decreased. If it is determined that the minimum heat storage amount is insufficient from the use result data, the stored hot water amount target value is increased with priority, and if the stored hot water amount target value reaches an upper limit value, the stored hot water temperature target value is increased. Thus, energy saving can be achieved.

FIG. 2



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Description

Technical Field

[0001] The present invention relates to a heat pump water heater and a method for controlling the same.

Background Art

[0002] Conventionally, as a heat pump water heater, a water heater disclosed by PTL 1 is known. PTL 1 discloses that a consumed heat amount in the last few days is stored, and when a current heat storage amount is smaller than the maximum consumed heat amount in the last few days, it is determined that shortage of hot water is likely to occur due to the large consumed heat amount, and thus, a remaining hot water amount at a time of starting heating is increased to start a heating operation early so as to prevent hot water shortage.

Citation List

Patent Literature

[0003]

{PTL 1}
Japanese Unexamined Patent Application, Publication No. 2004-60948

Summary of Invention

Technical Problem

[0004] In a case of a heat pump water heater, in general, a heat pump is operated to store hot water in a hot water storage tank during an off-peak period as inexpensive as possible, such as a night rate period (for example, from 0:00 to 8:00). In this case, it is preferable that electric power in the night rate period is used as efficiently as possible to avoid heating operation in a daytime rate period in which electric power rate is relatively expensive.

[0005] The present invention has been made in view of these circumstances, and an object of the present invention is to provide a heat pump water heater which sets an appropriate heat storage amount based on a past use result and uses as much electric power in a time period in which an electric power rate is relatively inexpensive as possible to perform heating, thereby allowing energy saving to be achieved, and a method for controlling a heat pump water heater. Solution to Problem

[0006] A first aspect of the present invention is a heat pump water heater performing heating so as to make hot water in a hot water storage tank have a preset stored hot water temperature target value and a preset stored hot water amount target value by using as much electric power in a time period in which an electric power rate is relatively inexpensive as possible, including: acquisition means acquiring a minimum heat storage amount per day from past use result data including a heat storage amount or a remaining hot water amount and a hot water supply load; target value change means changing at least one of the stored hot water temperature target value and the stored hot water amount target value when the minimum heat storage amount is higher than a predetermined proper range; and trial calculation means performing trial calculation of a minimum heat storage amount of a day by using the stored hot water temperature target value and the stored hot water amount target value after change and a hot water supply load of a day in the past use result data, and wherein, if the minimum heat storage amount is higher than an upper limit value of the proper range, the target value change means decreases the stored hot water temperature target value with priority until the minimum heat storage amount obtained by trial calculation by the trial calculation means falls within the proper range, and if the stored hot water temperature target value reaches a predetermined lower limit value, the target value change means decreases the stored hot water amount target value, while if the minimum heat storage amount is lower than a lower limit value of the proper range, the target value change means increases the stored hot water amount target value with priority until the minimum heat storage amount obtained by trial calculation by the trial calculation means falls within the proper range, and if the stored hot water amount target value reaches a predetermined upper limit value, the target value change means increases the stored hot water temperature target value.

[0007] Alternatively, a minimum remaining hot water amount may be used instead of the minimum heat storage amount.

[0008] According to the aforementioned heat pump water heater, in a case where the stored hot water temperature target value and the stored hot water amount target value for a next day and afterwards are changed depending on the use result data, if it is determined that the minimum heat storage amount is excessive from the use result data, the stored hot water temperature target value is decreased with priority, and if the stored hot water temperature target value reaches the lower limit value, the stored hot water amount target value is decreased. If it is determined that the minimum heat storage amount is insufficient from the use result data, the stored hot water amount target value is increased with priority, and if the stored hot water amount target value reaches the upper limit value, the stored hot water temperature target value is increased.

[0009] In this way, if a stored hot water temperature is set to be as low as possible and a hot water amount is set to be as large as possible, it is possible to operate a heat pump in an efficient operation range, and thus, energy saving can be achieved. Furthermore, by setting the stored hot water temperature to be as low as possible, it is possible to decrease precipitation of scale.

[0010] Since the stored hot water temperature target

value and the stored hot water amount target value are updated by referring to the use result data periodically, the heat storage amount is made appropriate so that energy saving can be achieved.

[0011] The heat pump water heater may have a configuration in which, the stored hot water temperature target value and the stored hot water amount target value are set for each day, the acquisition means acquires the minimum heat storage amount for each day, and the target value change means changes at least one of the stored hot water temperature target value and the stored hot water amount target value of a day in which the minimum heat storage amount is outside the proper range.

[0012] The heat pump water heater may have a configuration in which, the stored hot water temperature target value and the stored hot water amount target value are set for weekdays and for holidays, separately, the acquisition means acquires the minimum heat storage amount of weekdays and the minimum heat storage amount of holidays, separately, and the target value change means changes at least one of the stored hot water temperature target value and the stored hot water amount target value for weekdays if the heat storage amount of weekdays is outside the proper range, while changes at least one of the stored hot water temperature target value and the stored hot water amount target value for holidays if the minimum heat storage amount of holidays is outside the proper range.

[0013] The heat pump water heater may have a configuration in which, the acquisition means acquires the minimum heat storage amount from use result data of a previous day, and the target value change means changes at least one of the stored hot water temperature target value and the stored hot water amount target value if the minimum heat storage amount is higher than the predetermined proper range, and sets the stored hot water temperature target value and the stored hot water amount target value for a next day.

[0014] A second aspect of the present invention is a method for controlling a heat pump water heater performing heating so as to make hot water in a hot water storage tank have a preset stored hot water temperature target value and a preset stored hot water amount target value by using as much electric power of a time period in which an electric power rate is relatively as inexpensive as possible, the method including: an acquisition step of acquiring a minimum heat storage amount per day from past use result data including a heat storage amount, a remaining hot water amount and a hot water supply load; a target value change step of changing at least one of the stored hot water temperature target value and the stored hot water amount target value if the minimum heat storage amount is higher than a predetermined proper range; and a trial calculation step of performing trial calculation of a minimum heat storage amount of a day by using the stored hot water temperature target value and the stored hot water amount target value after change and a hot water supply load of a day in the past use result data, and wherein, in the target value change step, if the minimum heat storage amount is higher than an upper limit value of the proper range, the stored hot water temperature target value is decreased with priority until the minimum heat storage amount obtained by trial calculation by the trial calculation means falls within the proper range, and if the stored hot water temperature target value reaches a predetermined lower limit value, the stored hot water amount target value is decreased, while if the minimum heat storage amount is lower than a lower limit value of the proper range, the stored hot water amount target value is increased with priority until the minimum heat storage amount obtained by trial calculation by the trial calculation means falls within the proper range, and if the stored hot water amount target value reaches a predetermined upper limit value, the stored hot water temperature target value is increased. Advantageous Effects of Invention

[0015] The present invention provides an effect that energy saving can be achieved.

Brief Description of Drawings

[0016]

{Fig. 1}
Fig. 1 illustrates a schematic configuration of a heat pump water heater according to an embodiment of the present invention.
{Fig. 2}
Fig. 2 is a function block diagram of a hot water supply control unit illustrated in Fig. 1.
{Fig. 3}
Fig. 3 illustrates an example of minimum heat storage amounts for each day which are acquired by an acquisition unit illustrated in Fig. 2.
{Fig. 4}
Fig. 4 illustrates a general relationship between a performance coefficient and a stored hot water temperature of a heat source machine.
{Fig. 5}
Fig. 5 is a flowchart illustrating procedures of processing executed by a schedule updating unit.
{Fig. 6}
Fig. 6 is a flowchart illustrating procedures of processing executed by the schedule updating unit.
{Fig. 7}
Fig. 7 is a flowchart illustrating procedures of processing executed by the schedule updating unit.
{Fig. 8}
Fig. 8 is a flowchart illustrating procedures of processing executed by the schedule updating unit.
{Fig. 9}
Fig. 9 illustrates an example of a balance sheet of hot water supply load created based on use result data for a certain day stored in a use result data storage unit.
{Fig. 10}

Fig. 10 illustrates an example of the balance sheet of hot water supply load created from the use result data.

{Fig. 11}

Fig. 11 illustrates an example of the balance sheet of hot water supply load illustrated in Fig. 10, in which a stored hot water temperature target value and a stored hot water amount target value are changed such that a minimum heat storage amount obtained by trial calculation falls within a proper range.

{Fig. 12}

Fig. 12 illustrates an example of the balance sheet of hot water supply load created from the use result data.

{Fig. 13}

Fig. 13 illustrates an example of the balance sheet of hot water supply load illustrated in Fig. 12, in which a stored hot water temperature target value and a stored hot water amount target value are changed such that a minimum heat storage amount obtained by trial calculation falls within a proper range.

{Fig. 14}

Fig. 14 illustrates an example of the balance sheet of hot water supply load illustrated in Fig. 12, in which a stored hot water temperature target value and a stored hot water amount target value are changed such that a minimum heat storage amount obtained by trial calculation falls within a proper range.

Description of Embodiments

[0017] Hereinafter, description will be given of an embodiment of a heat pump type hot water heater and a method for controlling the same according to the present invention, with reference to the drawings.

[0018] Fig. 1 illustrates a schematic configuration of a heat pump water heater according to an embodiment of the present invention. As illustrated in Fig. 1, a heat pump water heater 1 includes a heat source machine 2 heating low-temperature water with a heat pump, and a hot water storage tank 3 which stores high-temperature water heated by the heat source machine 2.

[0019] In the heat pump water heater 1, low-temperature water is supplied to the hot water storage tank 3 by a water supply pump 5, via a water supply pipe 4. Low-temperature water supplied to the hot water storage tank 3 is fed to a circulation pipe 6, a flow rate of the low-temperature water is adjusted by a circulation pump (not illustrated) of the heat source machine 2 disposed in the circulation pipe 6, and the low-temperature water exchanges heat with a refrigerant having a high temperature in a heat exchanger for water (not illustrated) so that the low-temperature water is heated. High-temperature water after heating is fed back to the hot water storage tank 3 through the upper part of the hot water storage tank 3 via the circulation pipe 6. The high-temperature water stored in the hot water storage tank 3 is supplied to a non-illustrated hot water supply faucet such as a bathtub faucet via a hot water supply pipe 7.

[0020] In the hot water storage tank 3, a hot water amount sensor (not illustrated) for measuring a remaining hot water amount and a temperature sensor (not illustrated) for measuring a stored hot water temperature are disposed. In the water supply pipe 4, a flow rate sensor (not illustrated) for measuring a water supply amount is disposed. In the hot water supply pipe 7, a flow rate sensor (not illustrated) for measuring a hot water supply amount is disposed. A value measured by the aforementioned sensors is transmitted to a hot water supply control unit 10, which will be described below, and is stored in the hot water supply control unit 10 as use result data, and also is used for controlling the heat source machine and the like.

[0021] Heating control of low-temperature water in the heat pump water heater 1 is performed by the hot water supply control unit 10. The hot-water supply control unit 10 holds a schedule in which a stored hot water temperature target value and a stored hot water amount target value are set for each day. According to the schedule, the heat source machine 2 and the water supply pump 5 are operated so that a heat storage amount (stored hot water temperature x stored hot water amount) corresponding to the schedule is stored in the hot water storage tank 3. Here, heating operation of low-temperature water by the heat source machine 2 is performed by using as much electric power of a time period in which an electric power rate is relatively as inexpensive (for example, the night power rate, etc.) as possible.

[0022] Fig. 2 is a function block diagram of the hot water supply control unit 10. As illustrated in Fig. 2, the hot water supply control unit 10 includes a schedule storage unit 11, a use result data storage unit 12 that stores past use result data and a schedule updating unit 13 that updates a schedule stored in the schedule storage unit 11 based on the past usage result data. The hot water supply control unit 10 includes a non-illustrated water supply pump control unit that provides the water supply pump 5 with an operation command, a non-illustrated heating control unit that provides the heat source machine 2 with a command value of hot water target temperature, etc., and the like. For the flow rate control of the water supply pump 5 and the operation control of the heat source machine 2 which are performed based on the stored hot water temperature target value and the stored hot water amount target value, a known technique may be applied as appropriate, and thus, detailed description thereof is omitted.

[0023] In the schedule storage unit 11, a stored hot water temperature target value and a stored hot water amount target value for each day are set.

[0024] In the use result data storage unit 12, for example, a minimum heat storage amount, a remaining hot water amount, a hot water supply load, a heat source machine's heat capacity of a previous week and the like are stored as past use result data, while associating the data with a date and a day. Thereby, it is possible to

create, for example, a balance sheet of water supply load as illustrated in Fig. 9, based on certain use result data stored in the use result data storage unit 12, allowing a grasp of changes in heat storage amount of the hot water storage tank, hot water supply load, and heat source machine's heat capacity of a day.

[0025] The schedule updating unit 13 includes an acquisition unit 21, a target value change unit 22, and a trial calculation unit 23.

[0026] The acquisition unit 21 acquires a minimum heat storage amount for each day from the past use result data stored in the use result data storage unit 12. For example, the acquisition unit 21 reads out the use result data of the previous week from the use result data storage unit 12, and acquires the minimum heat storage amount for each day of the previous week, as illustrated in Fig. 3.

[0027] The target value change unit 22 determines whether a day in which the minimum heat storage amount is outside a preset predetermined proper range exists or not among the minimum heat storage amounts for each day acquired by the acquisition unit 21. If a day in which the minimum heat storage amount is outside the proper range exists, the target value change unit 22 changes the stored hot water temperature target value and the stored hot water amount target value of the day. For example, if heat storage amounts for each day acquired by the acquisition unit 22 result in ones illustrated in Fig. 3, the stored hot water temperature target values and the stored hot water amount target values for Mondays and Wednesdays are changed.

[0028] Specifically, if the minimum heat storage amount is higher than the upper limit value of the proper range, the target value change unit 22 decreases the stored hot water temperature target value with priority until the minimum heat storage amount obtained by trial calculation by the trial calculation unit 23, which will be described later, falls within the proper range. If the stored hot water temperature target value reaches a predetermined lower limit value, the target value change unit 23 decreases the stored hot water amount target value.

[0029] If the minimum heat storage amount is lower than the lower limit value of the proper range, the target value change unit 22 increases the stored hot water amount target value with priority until the minimum heat storage amount obtained by trial calculation by the trial calculation unit 23, which will be described later, falls within the proper range. If the stored hot water amount target value reaches a predetermined upper limit value, the target value change unit 22 increases the stored hot water temperature target value.

[0030] As illustrated in Fig. 4, in a heat source machine including a heat pump, generally, as a stored hot water temperature increases, a coefficient of performance (COP) decreases. The coefficient of performance is a value obtained by dividing a heat capacity (kW) by a consumed power (kW), and the higher coefficient of performance means higher efficiency. For this reason, in the present embodiment, when the stored hot water temperature target value and the stored hot water amount target amount are changed, the stored hot water temperature is set to be as low as possible so that the heat source machine 2 is operated in an efficient operation range. Thereby, reduction in power consumption is achieved.

[0031] Every time the stored hot water temperature target value or the stored hot water amount target amount is changed by the target value change unit 22, the trial calculation unit 23 refers to the past use result (supply hot water load, more specifically) of the day to perform trial calculation of a minimum heat storage amount for the changed stored hot water temperature target value or the changed stored hot water amount target amount. Specifically, the trial calculation unit 23 calculates a storage heat amount for each time period by multiplying the stored hot water temperature target value by the stored hot water amount target value in the changed operation pattern (operation time), and also operates change of the hot water storage tank in a day, from the supply hot water load for each time period of the past use result of the day, so that the minimum heat storage amount of the day is calculated.

[0032] Next, the procedures of processing executed by the aforementioned schedule updating unit 13 of the hot water supply control unit 10 are described, with reference to Fig. 5 to Fig. 8. The schedule updating unit 13 of the hot water supply control unit 10 executes the following processing to update the schedule, for example, once a week.

[0033] First, use result data of a previous week is read out from the use result data storage unit 12 (step SA1 in Fig. 5), and a minimum heat storage amount of each day is acquired (step SA2).

[0034] Then, it is determined whether a day in which a minimum heat storage amount is outside the predetermined proper range exists or not (step SA3), and if a day in which a heat storage amount is outside the predetermined proper range does not exist, it is determined that the schedule is not required to be updated and the processing is ended ("NO" in step SA3). In contrast, if a day in which a heat storage amount is outside the predetermined proper range exists, the day is extracted (step SA4) and target value change processing is respectively executed on each extracted day (step SA5).

[0035] In the target value change processing, first, it is determined whether the minimum heat storage amount of the extracted day is lower than the lower limit value of the proper range or not (step SB1 in Fig. 6), and if the minimum heat storage amount is not lower than the lower limit value of the proper range ("NO" in step SB1), it is determined that the minimum heat storage amount is higher than the upper limit value of the proper range to execute target value change processing for the purpose of reducing the heat storage amount (step SB2). If the minimum heat storage amount is lower than the lower limit value of the proper range ("YES" in step SB1), target value change processing is executed for the purpose of increasing the heat storage amount (step SB3).

[0036] In the target value change processing for the purpose of reducing the heat storage amount, first, it is determined whether the current stored hot water temperature target value is a preset lower limit value of a stored hot water temperature or not (step SC1 in Fig. 7), and if the stored hot water temperature target value is not the lower limit value

[0037] ("NO" in step SC1), the stored hot water temperature target value is changed to the lower limit value (step SC2). Thereafter, trial calculation of a minimum heat storage amount is performed with use of the changed target value (step SC3), and it is determined whether the minimum heat storage value obtained by trial calculation is within the proper range (step SC4). As a result of the determination, if not within the proper range ("NO" in step SC4), it is determined whether the minimum heat storage amount obtained by trial calculation in step SC3 is higher than the upper limit value of the proper range or not (step SC5).

[0038] As a result of the determination, if the minimum heat storage amount obtained by trial calculation is higher than the upper limit value of the proper range ("YES" in step SC5), the heat storage amount is required to be further decreased, and thus, the stored hot water amount target value is changed to a value decreased by a predetermined amount α (step SC6), and the processing returns to step SC3. In contrast, if the minimum heat storage amount obtained by trial calculation is equal to or lower than the upper limit value of the proper range in step SC5 ("NO" in step SC5), it is determined the minimum heat storage amount is lower than the lower limit value of the proper range. That is, in this case, due to change of the stored hot water temperature target value to the lower limit value in step SC2, the heat storage amount becomes too low, and the heat storage amount is required to be increased. Thus, the stored hot water temperature target value is increased by a predetermined value β (step SC7), and the processing returns to step SC3. Accordingly, trial calculation of the minimum heat storage amount is performed again with use of the updated target value (step SC3). Then, a loop from step SC3 to step SC7 is repeated until the minimum heat storage amount falls within the proper range in step SC4. If the minimum heat storage amount falls within the proper range ("YES" in step SC4), the schedule stored in the schedule storage unit 11 is updated to a target value as of that time (step SC8), and the processing is ended.

[0039] In the present processing, the stored hot water temperature target value is increased in step SC7. However, in a case where the stored hot amount is still insufficient even if the stored hot water amount is increased to the upper limit value by increasing the stored hot water to increase the heat storage amount, the stored hot water temperature target value may be increased. In such processing, the stored hot water temperature target value can be set to be as low as possible, and thus, the heat source machine 2 can be operated in an efficient temperature range.

[0040] In the target value change processing for the purpose of increasing the heat storage amount in step SB3 in Fig. 6, first, it is determined whether a current stored hot water amount target value is the upper limit value of the preset stored hot water amount (step SD1 in Fig. 8). If the current stored hot water amount target value is not the upper limit value ("NO" in step SD1), the stored hot water amount target value is changed to a value increased by a predetermined value α (step SD2). At that time, the stored hot water amount target value is increased with the upper limit value of the stored hot water amount as an upper limit. Thereafter, trial calculation of a minimum heat storage amount is performed by using the changed target value (step SD3), and it is determined whether the minimum heat storage amount obtained by trial calculation is within the proper range (step SD4). As a result of the determination, if the minimum heat storage amount is not within the proper range ("NO" in step SD4), the processing returns to step SD1.

[0041] Accordingly, until the minimum heat storage amount obtained by trial calculation falls within the proper range or the stored hot water amount target value reaches the upper limit value, the processing from steps SD1 to SD4 is repeatedly executed so that the stored hot water amount target value is stepwise increased. If the stored hot water amount reaches the upper limit value before the minimum heat storage amount obtained by trial calculation in step SD3 falls within the proper range ("YES" in step SD1), it is determined whether the stored hot water temperature target value is the upper limit value or not (step SD5). As a result of the determination, if the stored hot water temperature target value is not the upper limit value ("NO" in step SD5), the stored hot water temperature target value is changed to a value increased by the predetermined value β (step SD6). Here, the stored hot water temperature target value is increased with the upper limit value of the stored hot water temperature as an upper limit. Then, the changed target value is used to perform trial calculation of the minimum heat storage amount (step SD7), and it is determined whether the minimum heat storage amount obtained by trial calculation is within the proper range (step SD8).

[0042] As a result of the determination, if the minimum heat storage amount obtained by trial calculation is within the proper range ("YES" in step SD8), the target value as of that time is written into the schedule to update the schedule (step SD9). In contrast, if the minimum heat storage amount is not within the proper range in step SD8, the processing returns to step SD5. Accordingly, until the minimum heat storage amount obtained by trial calculation falls within the proper range or the stored hot water temperature target value reaches the upper limit, the processing of increasing the stored hot water temperature target value is repeated. If the minimum heat storage amount falls within the proper range before the stored hot water temperature target value reaches the upper limit value ("YES" in step SD8), the target value as of that time is written into the schedule to update the

schedule, and the processing is ended.

[0043] In contrast, if the stored hot water temperature target value reaches the upper limit value before the minimum heat storage amount falls within the proper range, the heat storage amount cannot be increased any more. In this case, the schedule is updated, for example, by writing the upper limit values of the stored hot water temperature target value and the stored hot water amount target value into the schedule. In this case, there is a high possibility that a heat amount stored in the hot water storage tank 3 with night electric power is lower than a consumption amount. Therefore, there is a need for a measure such as increasing a hot water amount to be stored in the hot water storage tank by operating a heat pump during the daytime, for example. In this case, for example, if the remaining hot water amount in the hot water storage tank 3 is equal to or lower than a predetermined threshold, it is possible to take a measure such as operating the heat source machine 2.

[0044] Fig. 9 to Fig. 14 illustrate an example of a balance sheet of hot water supply load for a day. Fig. 9 illustrates a case where a minimum heat storage amount of the day is within the proper range. Fig. 10, which illustrates an example of a balance sheet of hot water supply load created from the use result data, illustrates a case where the minimum heat storage amount of the day is higher than the upper limit value of the proper range. In this case, the aforementioned processing of changing the target value for the purpose of decreasing the heat storage amount illustrated in Fig. 7 is executed, and thus, the stored hot water temperature target value and the stored hot water amount target value are changed such that the minimum heat storage amount obtained by trial calculation is within the proper range, as illustrated in Fig. 11.

[0045] Fig. 12, which illustrates an example of the balance sheet of hot water supply load created from the use result data, illustrates a case where the minimum heat storage amount of the day is lower than the lower limit value of the proper range. In this case, the aforementioned processing of changing the target value for the purpose of increasing the heat storage amount illustrated in Fig. 8 is executed, and thus, the stored hot water temperature target value and the stored hot water amount target value are changed such that the minimum heat storage amount obtained by trial calculation is within the proper range, as illustrated in Fig. 13. In Fig. 13, for example, it is found that, in the schedule, the operation time period of the heat source machine 2 is extended by an hour due to increase in stored hot water amount target value, and the operation is stopped at nine o'clock. In this way, in a case where even if the heat source machine 2 is operated during a night rate period, the stored hot water temperature target value and the stored hot water amount target value which are set in the schedule are not achieved, it is required to operate the heat source machine 2 also in a normal rate period. In Fig. 13, a predetermined heat storage amount is secured by continuously extending the operation time period of the heat source machine 2, while in Fig. 14, a heat storage amount is increased by temporarily stopping the operation of the heat source machine 2 at eight o'clock when the night power rate period ends, and operating again the heat source machine 2 in the time period when the hot water supply load increases (here, a time period from 18:00 to 19:00).

[0046] As described so far, according to the heat pump water heater 1 of the present embodiment, in a case where the stored hot water temperature target value and the stored hot water amount target value of a next day and afterwards are changed depending on use result data, if it is determined that the heat storage amount is excessive from the use result data, the stored hot water temperature target value is decreased with priority, and if the stored hot water temperature target value reaches the lower limit value, the stored hot water amount target value is decreased. If it is determined that the heat storage amount is insufficient from the use result data, the stored hot water amount target value is increased with priority, and if the stored hot water amount target value reaches the upper limit value, the stored hot water temperature target value is increased.

[0047] In this way, if the stored hot water temperature is set to be as low as possible and the hot water amount is set to be as large as possible, it is possible to operate the heat source machine 2 in an efficient operation range, and thus, energy saving can be achieved. By setting the stored hot water temperature to be as low as possible, it is possible to decrease precipitation of scale.

[0048] The schedule is updated by referring to the use result data periodically, and thus, the heat storage amount is made appropriate so that efficient heating is possible. Accordingly, energy saving can be achieved.

[0049] In the present embodiment, the stored hot water temperature target value and the stored hot water amount target value are set for each day, but the present invention is not limited to this. For example, the stored hot water temperature target value and the stored hot water amount target value of a certain day may be set based on use result data of a previous day, or the stored hot water temperature target value and the stored hot water amount target value may be set for weekdays and for holidays, separately. In this case, for a minimum heat storage amount for weekdays/holidays, an average value may be used, or the lowest minimum heat storage amount of the minimum heat storage amounts may be used.

[0050] In the present embodiment, the stored hot water temperature target value and the stored hot water amount target value are changed with use of the minimum heat storage amount, but such stored hot water temperature target value and stored hot water amount target value may be changed with use of a minimum remaining hot water amount instead of the minimum heat storage amount.

[0051] The present invention is not limited only to the

aforementioned embodiment, and various modifications can be performed within a scope of the present invention.

{Reference Signs List}

[0052]

1 heat pump water heater
2 heat source machine
3 hot water storage tank
4 water supply pipe
5 water supply pump
6 circulation pipe
7 hot water supply pipe
10 hot water supply control unit
11 schedule storage unit
12 use result data storage unit
13 schedule updating unit
21 acquisition unit
22 target value change unit
23 trial calculation unit

Claims

1. A heat pump water heater performing heating so as to make hot water in a hot water storage tank (3) have a preset stored hot water temperature target value and a preset stored hot water amount target value by using as much electric power in a time period in which an electric power rate is relatively as inexpensive as possible, **characterized in that** it comprises:

acquisition means (21) configured to acquire a minimum heat storage amount per day from past use result data including a heat storage amount or a remaining hot water amount and a hot water supply load;
target value change means (22) configured to change at least one of the stored hot water temperature target value and the stored hot water amount target value when the minimum heat storage amount is higher than a predetermined proper range; and
trial calculation means (23) configured to perform trial calculation of a minimum heat storage amount of a day by using the stored hot water temperature target value and the stored hot water amount target value after change and a hot water supply load of a day in the past use result data, wherein,
if the minimum heat storage amount is higher than an upper limit value of the proper range, the target value change means (22) decreases the stored hot water temperature target value with priority until the minimum heat storage amount obtained by trial calculation by the trial calculation means (23) falls within the proper range, and if the stored hot water temperature target value reaches a predetermined lower limit value, the target value change means (22) decreases the stored hot water amount target value, and
if the minimum heat storage amount is lower than a lower limit value of the proper range, the target value change means (22) increases the stored hot water amount target value with priority until the minimum heat storage amount obtained by trial calculation by the trial calculation means (23) falls within the proper range, and if the stored hot water amount target value reaches a predetermined upper limit value, the target value change means (22) increases the stored hot water temperature target value.

2. The heat pump water heater of Claim 1, wherein
the stored hot water temperature target value and the stored hot water amount target value are set for each day,
the acquisition means (21) acquires the minimum heat storage amount for each day, and
the target value change means (22) changes at least one of the stored hot water temperature target value and the stored hot water amount target value for a day in which the minimum heat storage amount is outside the proper range.

3. The heat pump water heater of Claim 1, wherein
the stored hot water temperature target value and the stored hot water amount target value are set for weekdays and for holidays, separately,
the acquisition means (21) acquires the minimum heat storage amount for weekdays and for holidays, separately, and
the target value change means (22) changes at least one of the stored hot water temperature target value and the stored hot water amount target value for weekdays if the minimum heat storage amount of weekdays is outside the proper range, and changes at least one of the stored hot water temperature target value and the stored hot water amount target value for holidays if the minimum heat storage amount of holidays is outside the proper range.

4. The heat pump water heater of Claim 1, wherein
the acquisition means (21) acquires the minimum heat storage amount from use result data of a previous day, and
the target value change means (22) changes at least one of the stored hot water temperature target value and the stored hot water amount target value if the minimum heat storage amount is higher than the predetermined proper range, and sets the stored hot water temperature target value and the stored hot water amount target value for a next day.

5. The heat pump water heater of any one of Claims 1 to 4, wherein a minimum remaining hot water amount is used instead of the minimum heat storage amount.

6. A method for controlling a heat pump water heater performing heating so as to make hot water in a hot water storage tank (3) have a preset stored hot water temperature target value and a preset stored hot water amount target value by using as much electric power in a time period in which an electric power rate is relatively as inexpensive as possible, the method being **characterized in that** it comprises:

an acquisition step of acquiring a minimum heat storage amount per day from past use result data including a heat storage amount or a remaining hot water amount and a hot water supply load;
a target value change step of changing at least one of the stored hot water temperature target value and the stored hot water amount target value if the minimum heat storage amount is higher than a predetermined proper range; and
a trial calculation step of performing trial calculation of a minimum heat storage amount of a day by using the stored hot water temperature target value and the stored hot water amount target value after change and a hot water supply load of a day in the past use result data, wherein,
in the target value change step,
if the minimum heat storage amount is higher than an upper limit value of the proper range, the stored hot water temperature target value is decreased with priority until the minimum heat storage amount obtained by trial calculation in the trial calculation step falls within the proper range, and if the stored hot water temperature target value reaches a predetermined lower limit value, the stored hot water amount target value is decreased, and
if the minimum heat storage amount is lower than a lower limit value of the proper range, the stored hot water amount target value is increased with priority until the minimum heat storage amount obtained by trial calculation in the trial calculation step falls within the proper range, and if the stored hot water amount target value reaches a predetermined upper limit value, the stored hot water temperature target value is increased.

FIG. 1

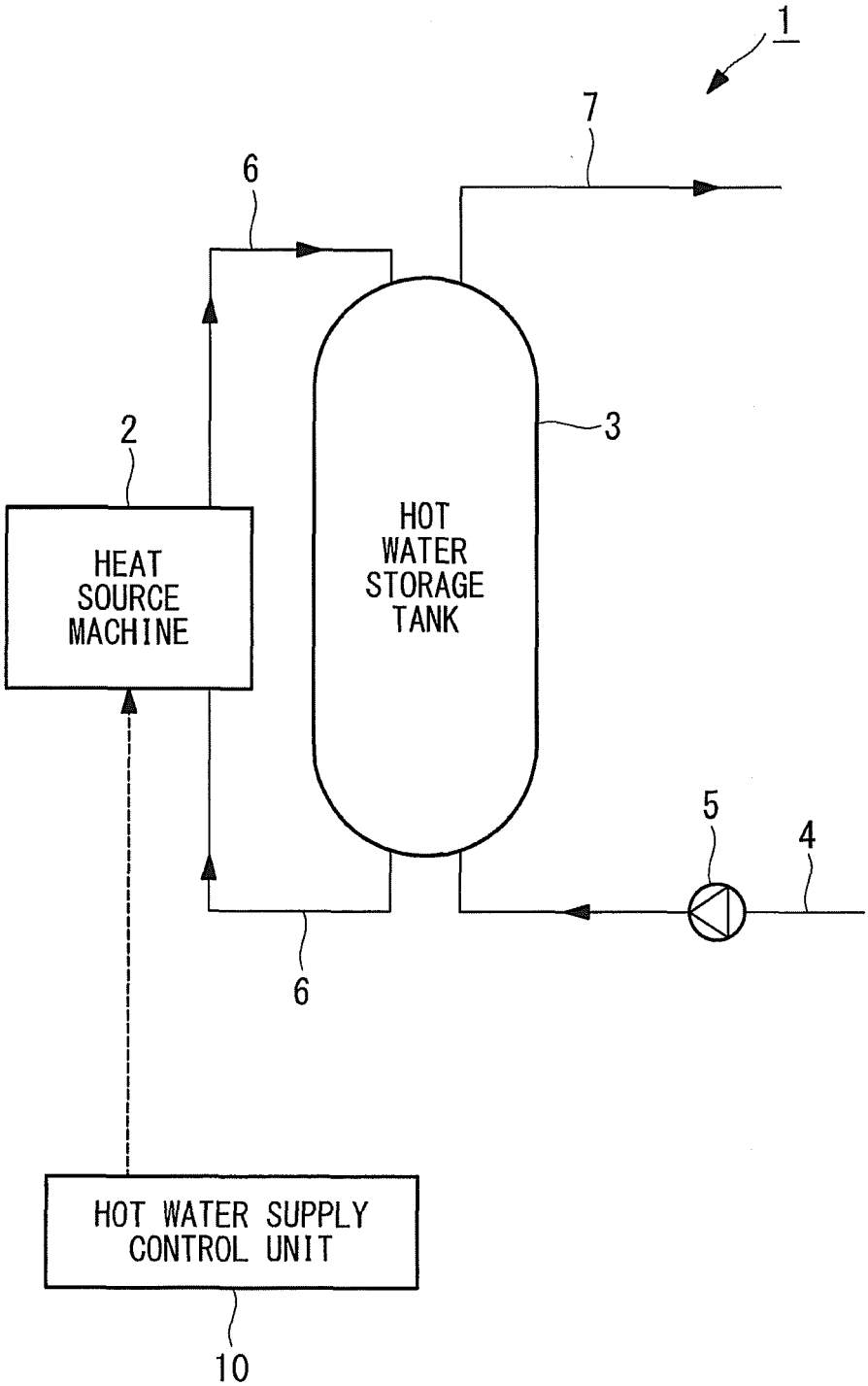

1
7
6
2
3
HEAT SOURCE MACHINE
HOT WATER STORAGE TANK
5
4
6
HOT WATER SUPPLY CONTROL UNIT
10

FIG. 2

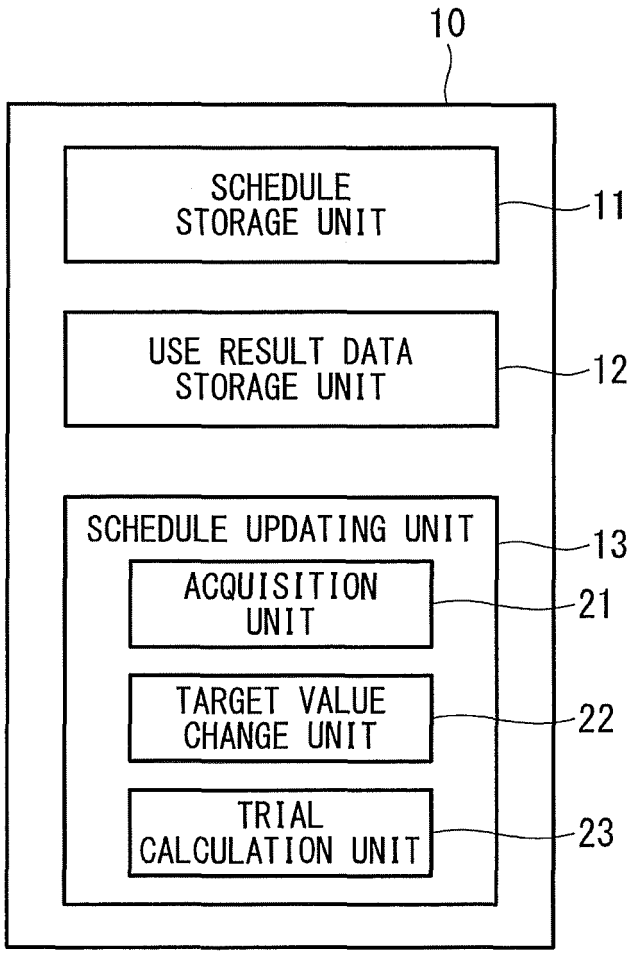

10
SCHEDULE STORAGE UNIT
11
USE RESULT DATA STORAGE UNIT
12
SCHEDULE UPDATING UNIT
13
ACQUISITION UNIT
21
TARGET VALUE CHANGE UNIT
22
TRIAL CALCULATION UNIT
23

FIG. 3

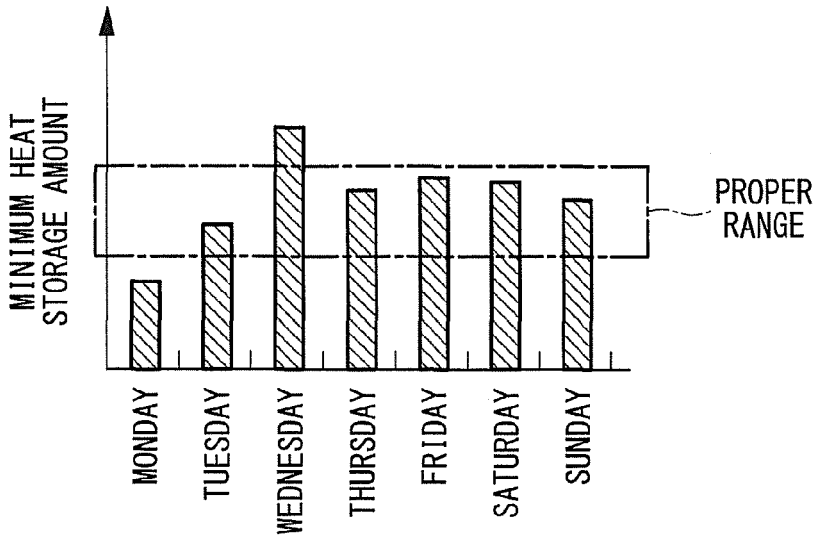

MINIMUM HEAT STORAGE AMOUNT
PROPER RANGE
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY

FIG. 4

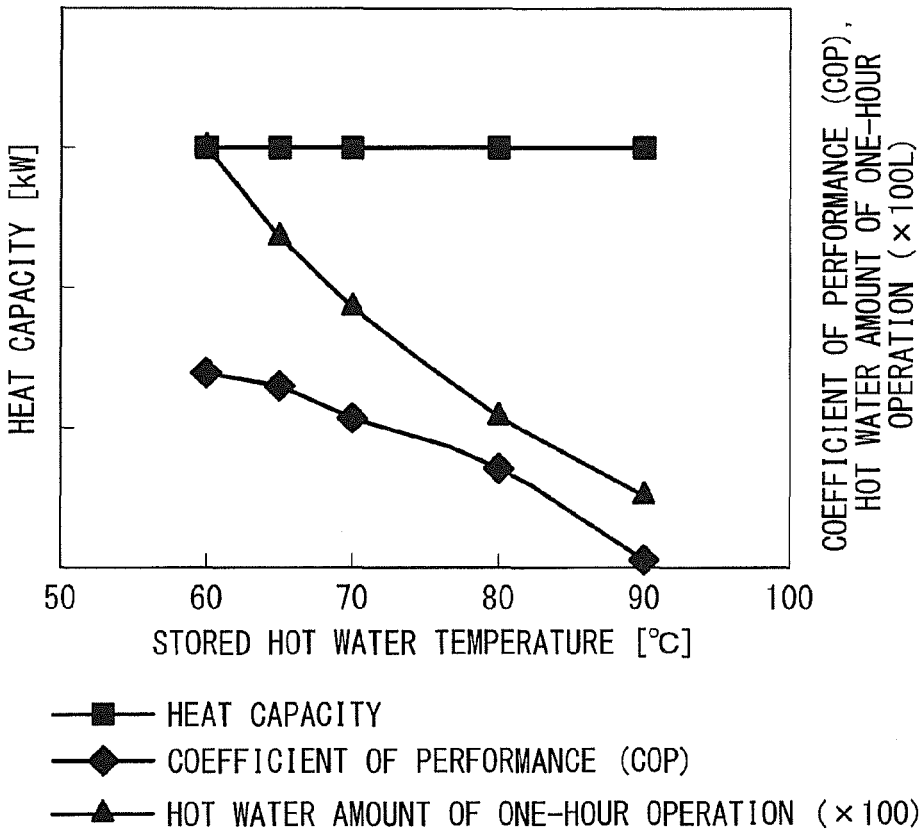

HEAT CAPACITY [kW]
COEFFICIENT OF PERFORMANCE (COP), HOT WATER AMOUNT OF ONE-HOUR OPERATION (×100L)
50
60
70
80
90
100
STORED HOT WATER TEMPERATURE [℃]
HEAT CAPACITY
COEFFICIENT OF PERFORMANCE (COP)
HOT WATER AMOUNT OF ONE-HOUR OPERATION (×100)

FIG. 5

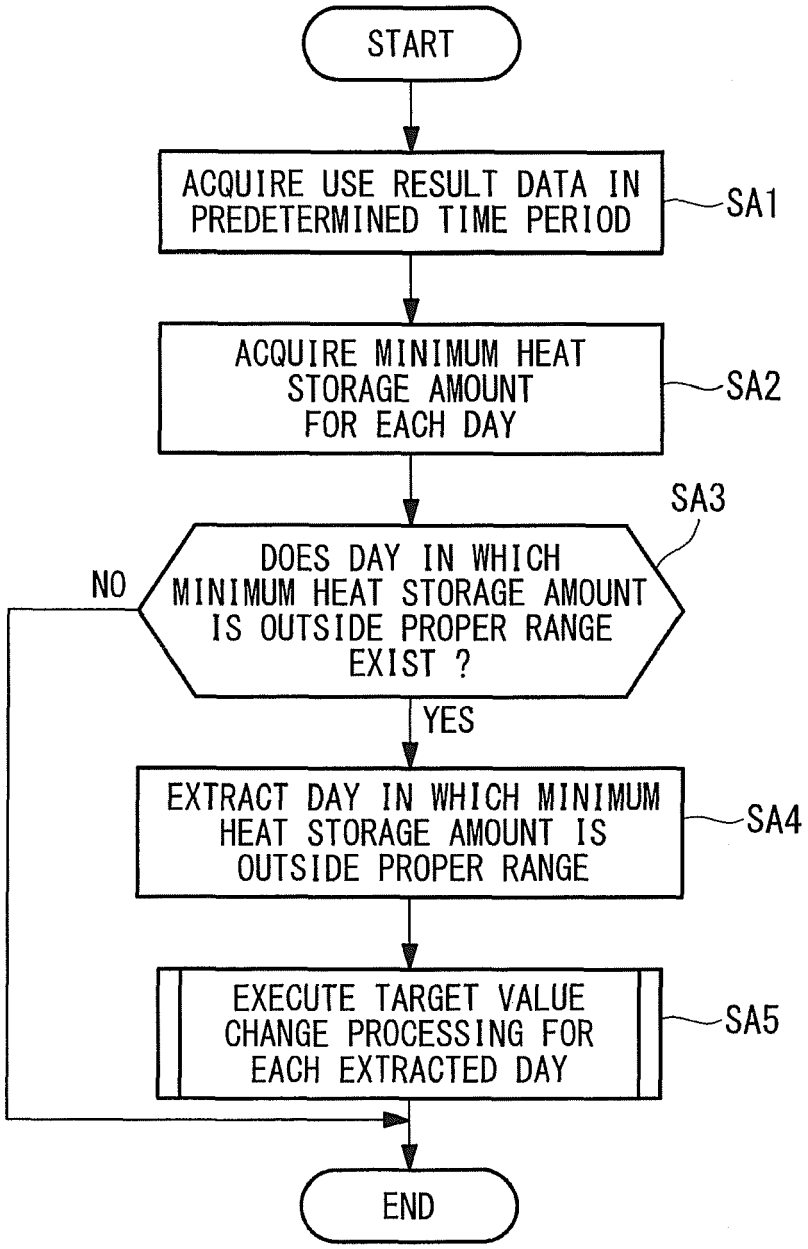

START
ACQUIRE USE RESULT DATA IN PREDETERMINED TIME PERIOD
SA1
ACQUIRE MINIMUM HEAT STORAGE AMOUNT FOR EACH DAY
SA2
SA3
DOES DAY IN WHICH MINIMUM HEAT STORAGE AMOUNT IS OUTSIDE PROPER RANGE EXIST ?
NO
YES
EXTRACT DAY IN WHICH MINIMUM HEAT STORAGE AMOUNT IS OUTSIDE PROPER RANGE
SA4
EXECUTE TARGET VALUE CHANGE PROCESSING FOR EACH EXTRACTED DAY
SA5
END

FIG. 6

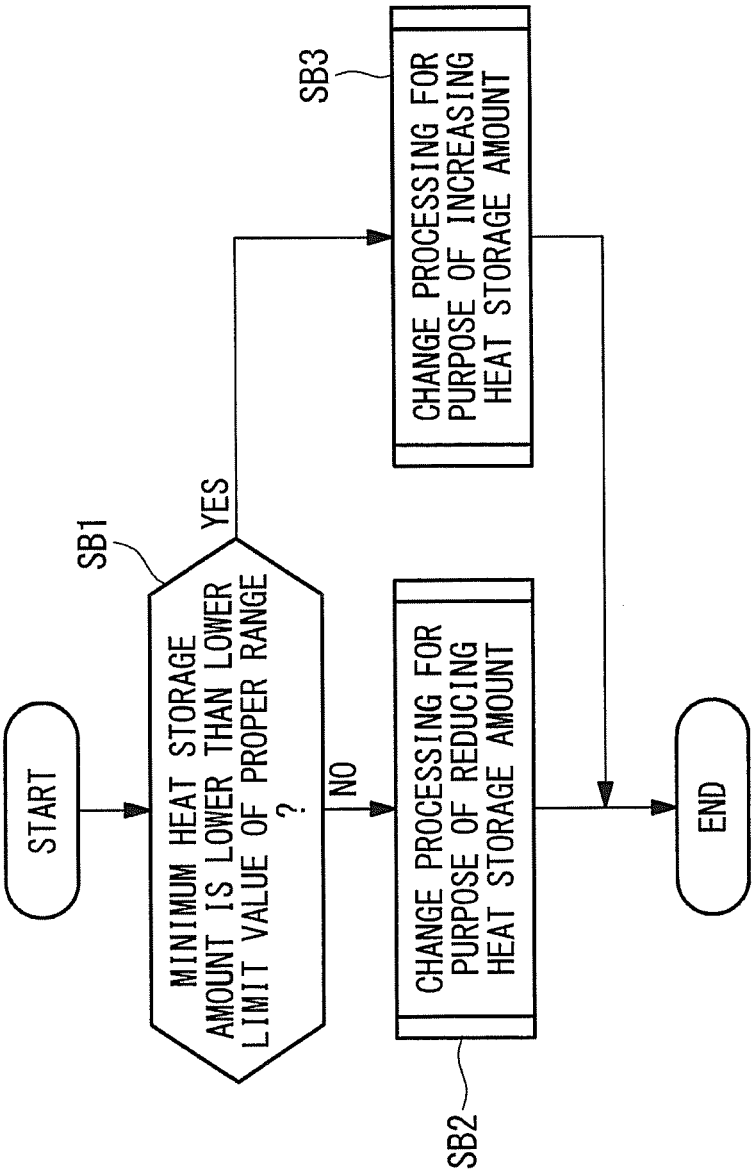

START
SB1
MINIMUM HEAT STORAGE AMOUNT IS LOWER THAN LOWER LIMIT VALUE OF PROPER RANGE ?
YES
NO
SB3
CHANGE PROCESSING FOR PURPOSE OF INCREASING HEAT STORAGE AMOUNT
SB2
CHANGE PROCESSING FOR PURPOSE OF REDUCING HEAT STORAGE AMOUNT
END

FIG. 7

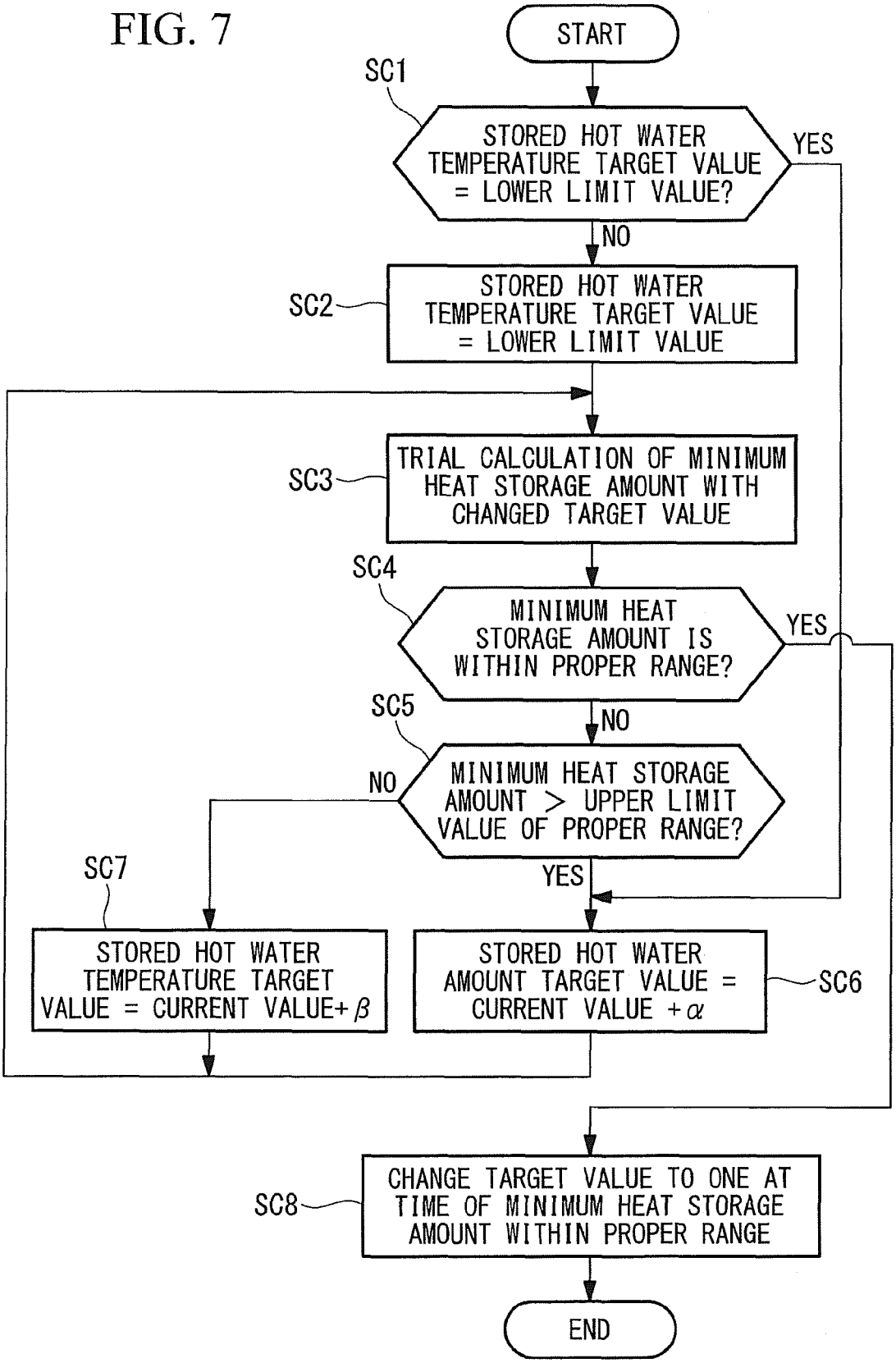

START
SC1
STORED HOT WATER TEMPERATURE TARGET VALUE = LOWER LIMIT VALUE?
YES
NO
SC2
STORED HOT WATER TEMPERATURE TARGET VALUE = LOWER LIMIT VALUE
SC3
TRIAL CALCULATION OF MINIMUM HEAT STORAGE AMOUNT WITH CHANGED TARGET VALUE
SC4
MINIMUM HEAT STORAGE AMOUNT IS WITHIN PROPER RANGE?
YES
NO
SC5
MINIMUM HEAT STORAGE AMOUNT > UPPER LIMIT VALUE OF PROPER RANGE?
NO
YES
SC7
STORED HOT WATER TEMPERATURE TARGET VALUE = CURRENT VALUE+β
STORED HOT WATER AMOUNT TARGET VALUE = CURRENT VALUE +α
SC6
SC8
CHANGE TARGET VALUE TO ONE AT TIME OF MINIMUM HEAT STORAGE AMOUNT WITHIN PROPER RANGE
END

FIG. 8

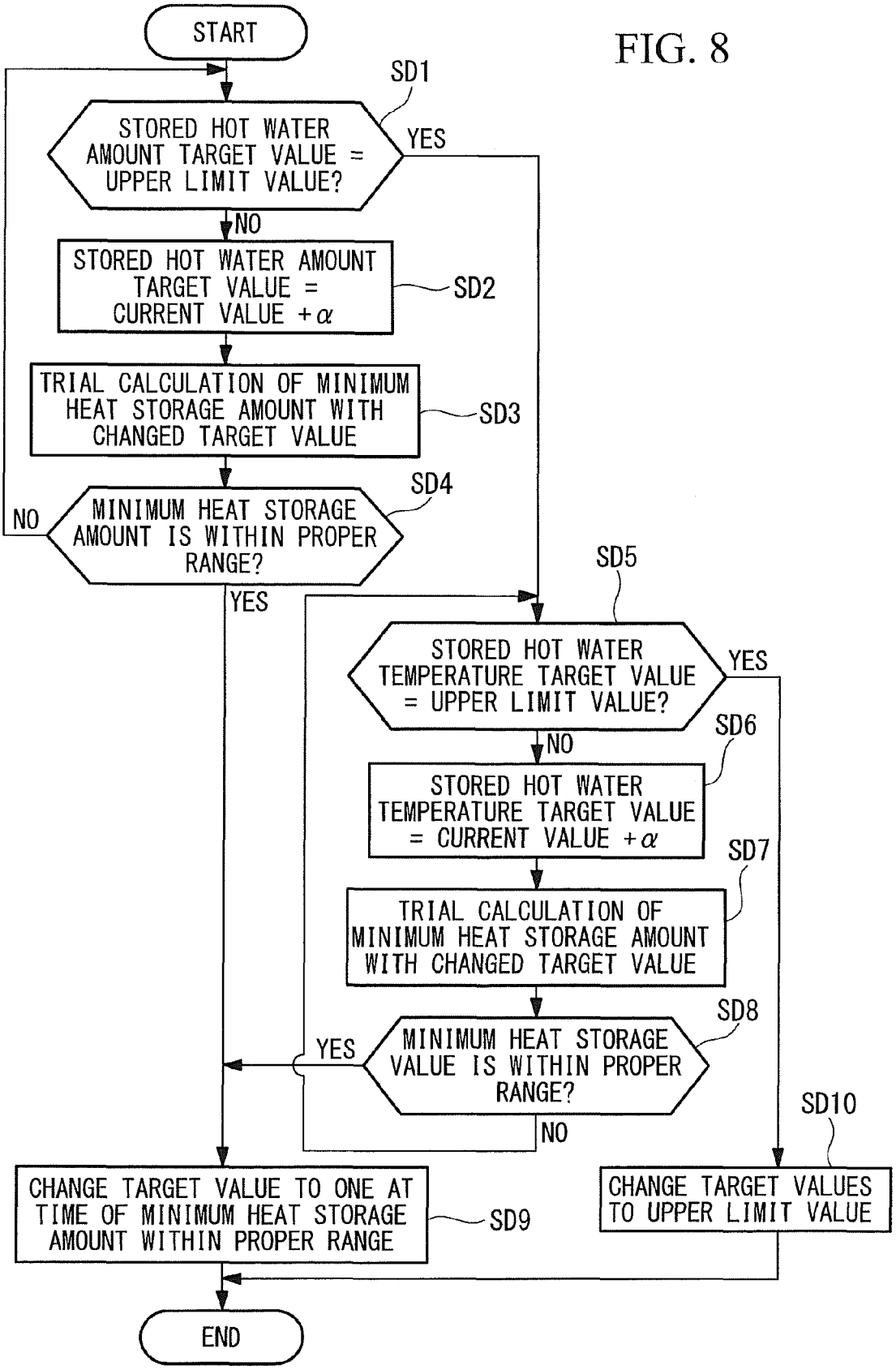

START
SD1
STORED HOT WATER AMOUNT TARGET VALUE = UPPER LIMIT VALUE?
YES
NO
STORED HOT WATER AMOUNT TARGET VALUE = CURRENT VALUE +α
SD2
TRIAL CALCULATION OF MINIMUM HEAT STORAGE AMOUNT WITH CHANGED TARGET VALUE
SD3
SD4
NO
MINIMUM HEAT STORAGE AMOUNT IS WITHIN PROPER RANGE?
YES
SD5
STORED HOT WATER TEMPERATURE TARGET VALUE = UPPER LIMIT VALUE?
YES
NO
SD6
STORED HOT WATER TEMPERATURE TARGET VALUE = CURRENT VALUE +α
SD7
TRIAL CALCULATION OF MINIMUM HEAT STORAGE AMOUNT WITH CHANGED TARGET VALUE
SD8
YES
MINIMUM HEAT STORAGE VALUE IS WITHIN PROPER RANGE?
NO
SD10
CHANGE TARGET VALUE TO ONE AT TIME OF MINIMUM HEAT STORAGE AMOUNT WITHIN PROPER RANGE
SD9
CHANGE TARGET VALUES TO UPPER LIMIT VALUE
END

FIG. 9

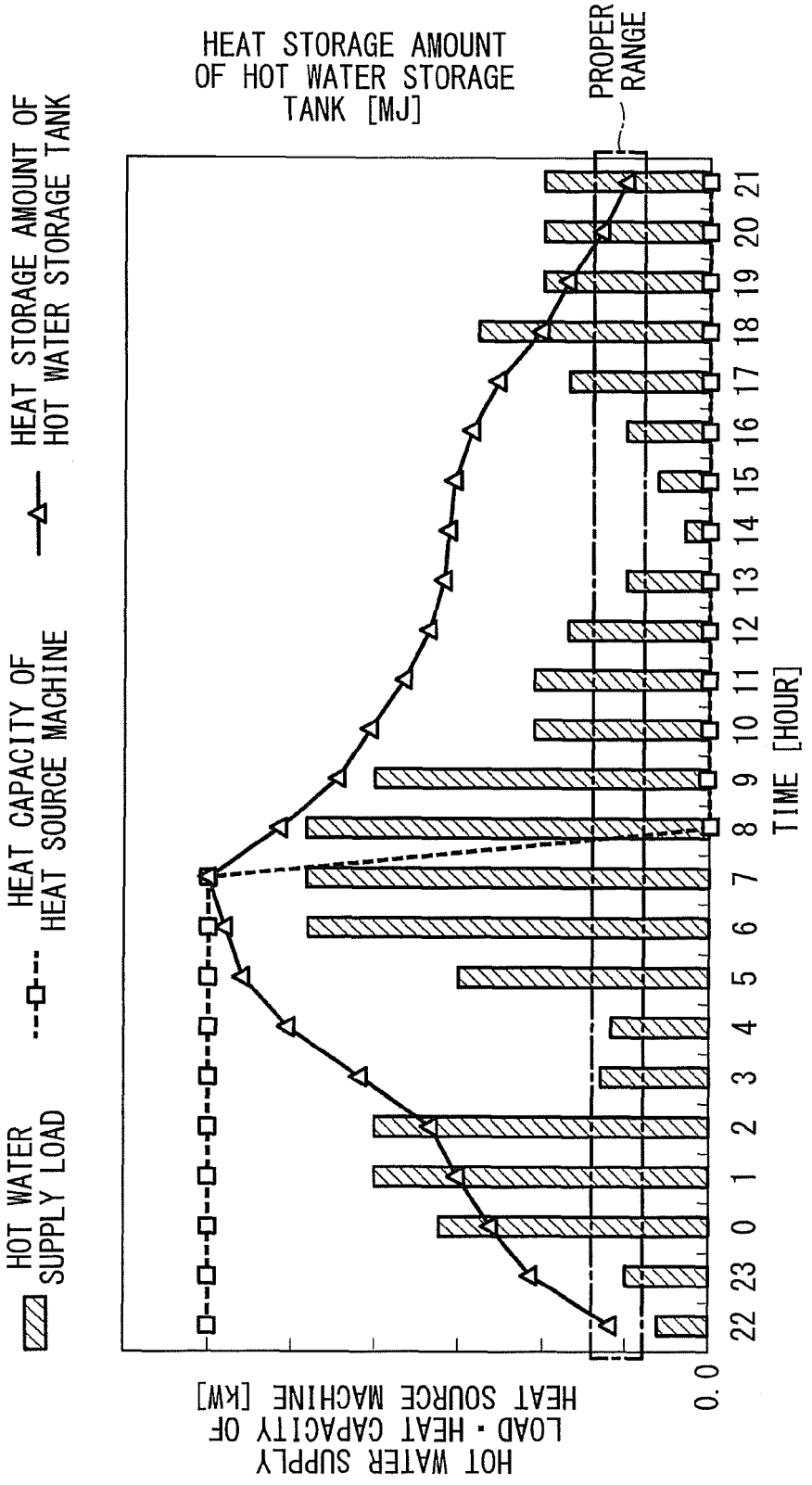

HOT WATER SUPPLY LOAD
HEAT CAPACITY OF HEAT SOURCE MACHINE
HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK
HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK [MJ]
PROPER RANGE
HOT WATER SUPPLY LOAD · HEAT CAPACITY OF HEAT SOURCE MACHINE [kW]
0.0
22 23 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
TIME [HOUR]

FIG. 10

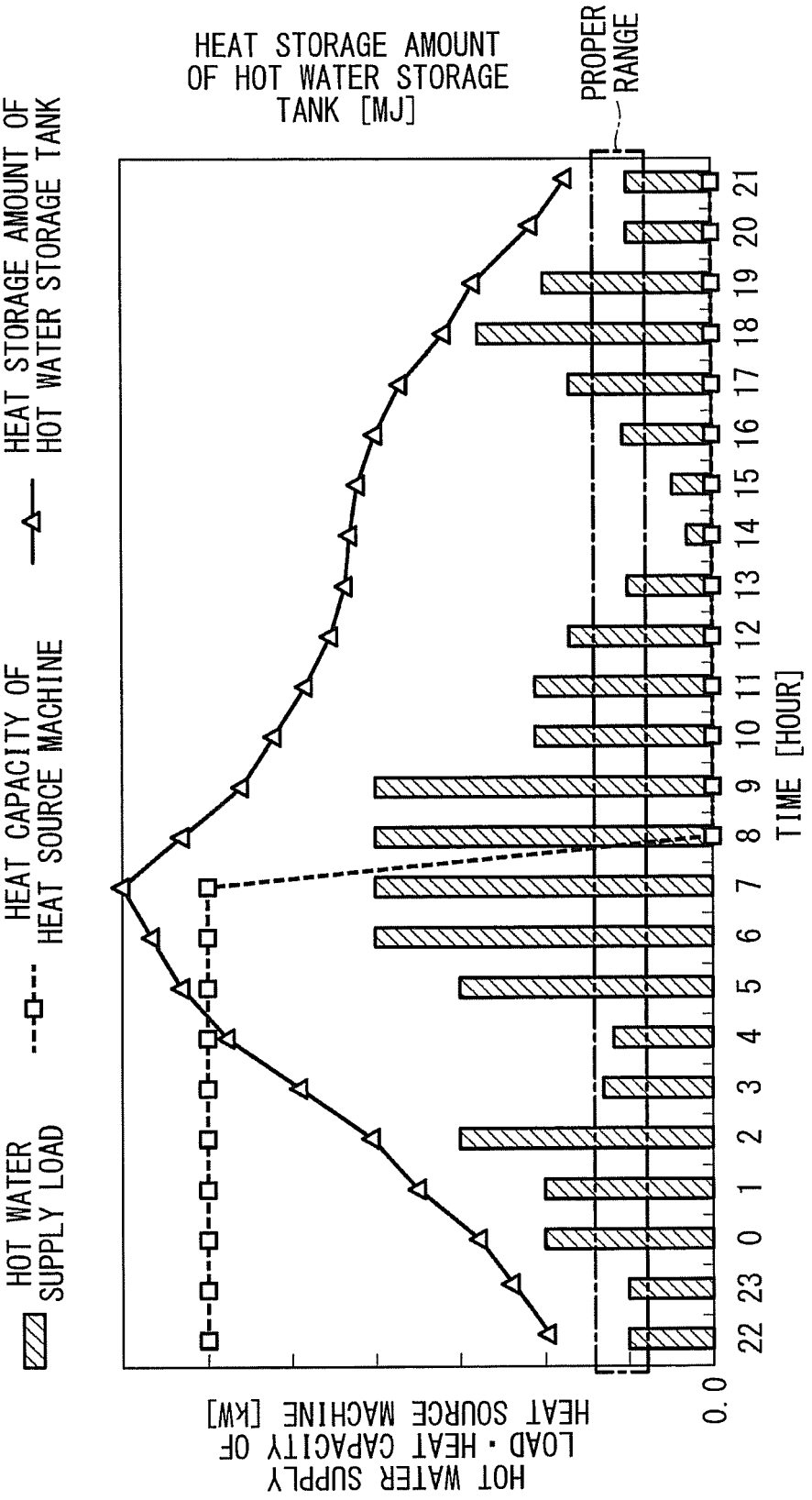

HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK [MJ]
PROPER RANGE
HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK
HEAT CAPACITY OF HEAT SOURCE MACHINE
HOT WATER SUPPLY LOAD
HOT WATER SUPPLY LOAD · HEAT CAPACITY OF HEAT SOURCE MACHINE [KW]
0.0
22 23 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
TIME [HOUR]

FIG. 11

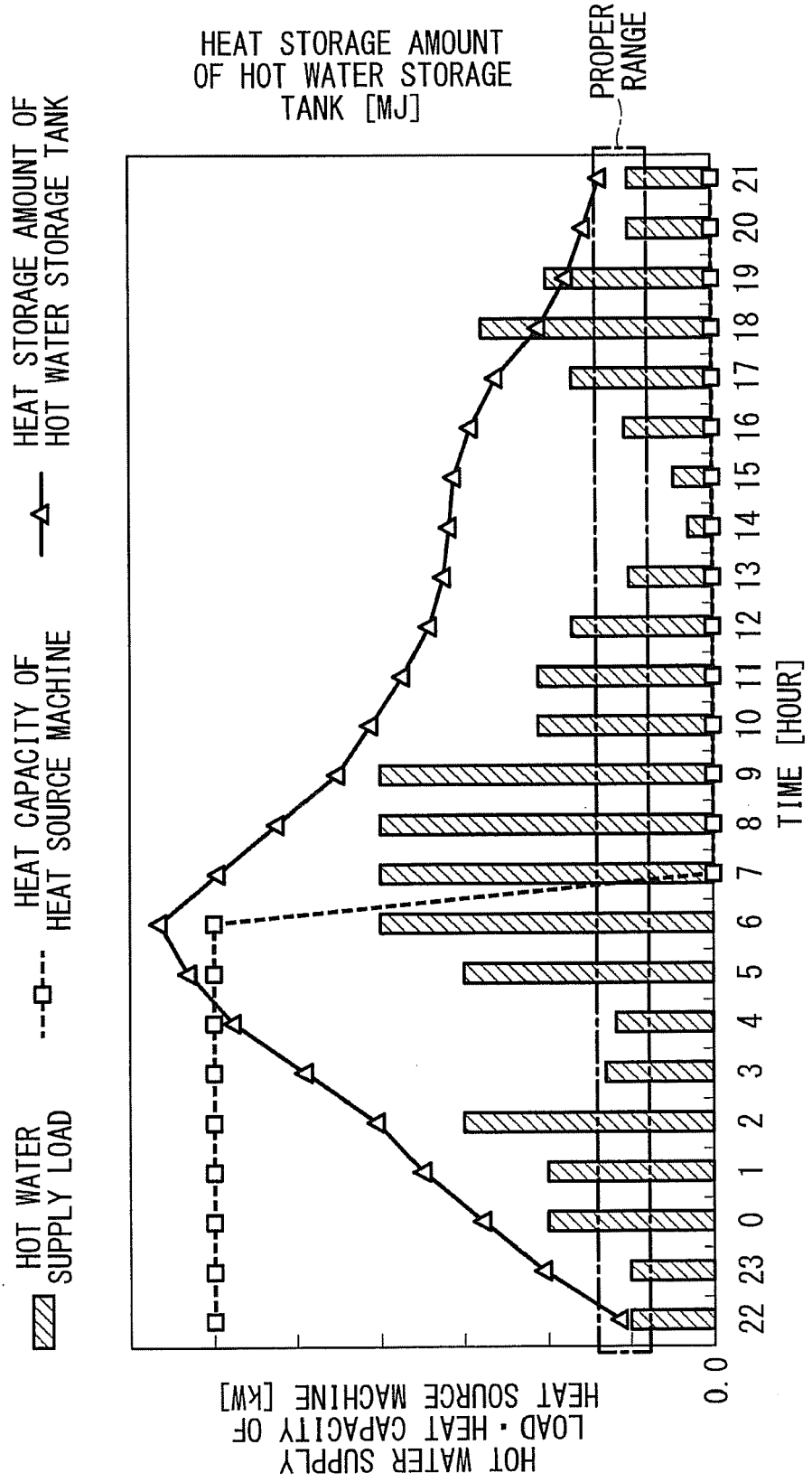

HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK [MJ]
PROPER RANGE
HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK
HEAT CAPACITY OF HEAT SOURCE MACHINE
HOT WATER SUPPLY LOAD
HOT WATER SUPPLY LOAD · HEAT CAPACITY OF HEAT SOURCE MACHINE [kW]
0.0
22 23 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
TIME [HOUR]

FIG. 12

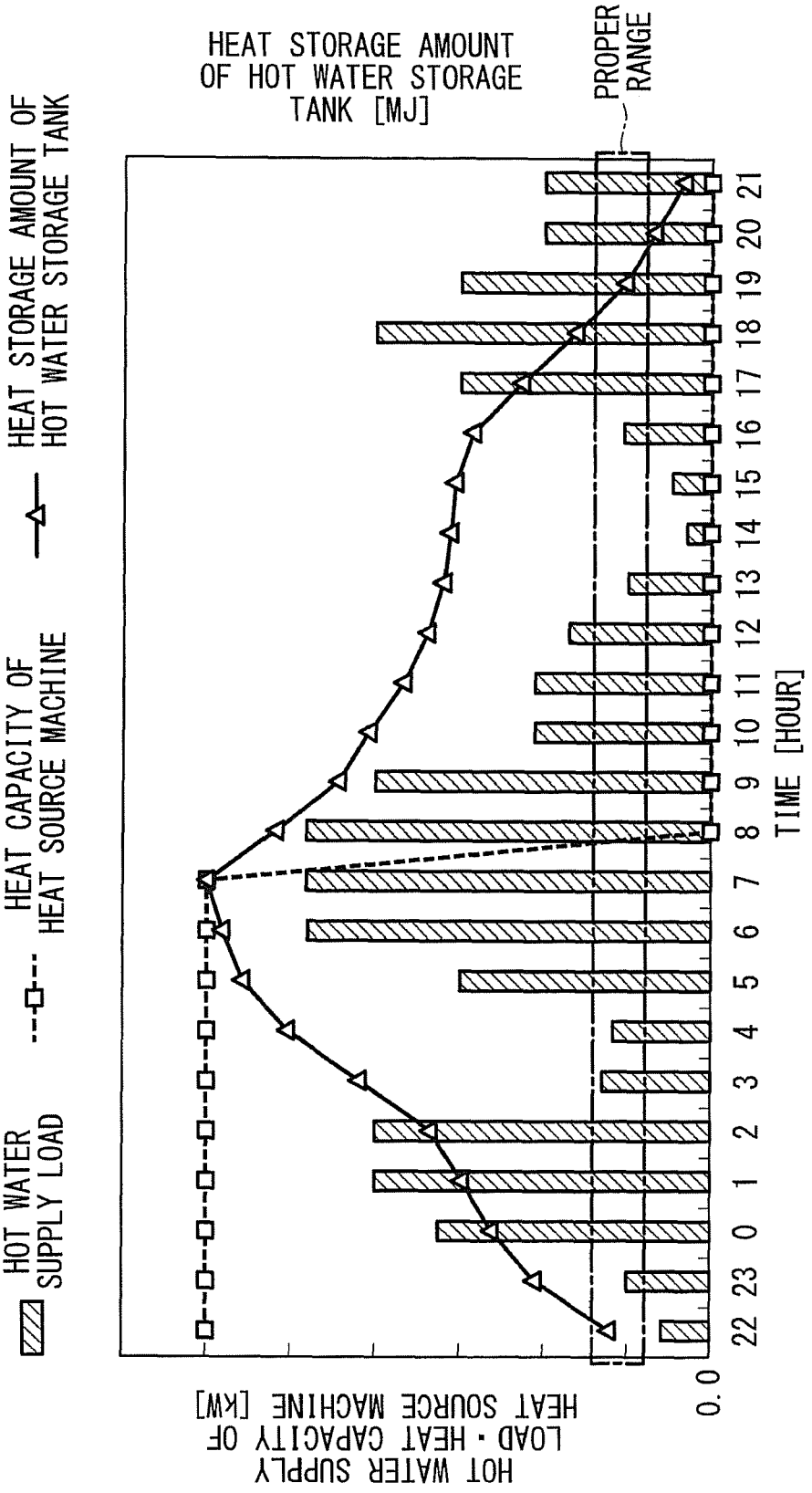

HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK [MJ]
PROPER RANGE
HOT WATER SUPPLY LOAD
HEAT CAPACITY OF HEAT SOURCE MACHINE
HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK
HOT WATER SUPPLY LOAD · HEAT CAPACITY OF HEAT SOURCE MACHINE [kW]
0.0
22 23 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
TIME [HOUR]

FIG. 13

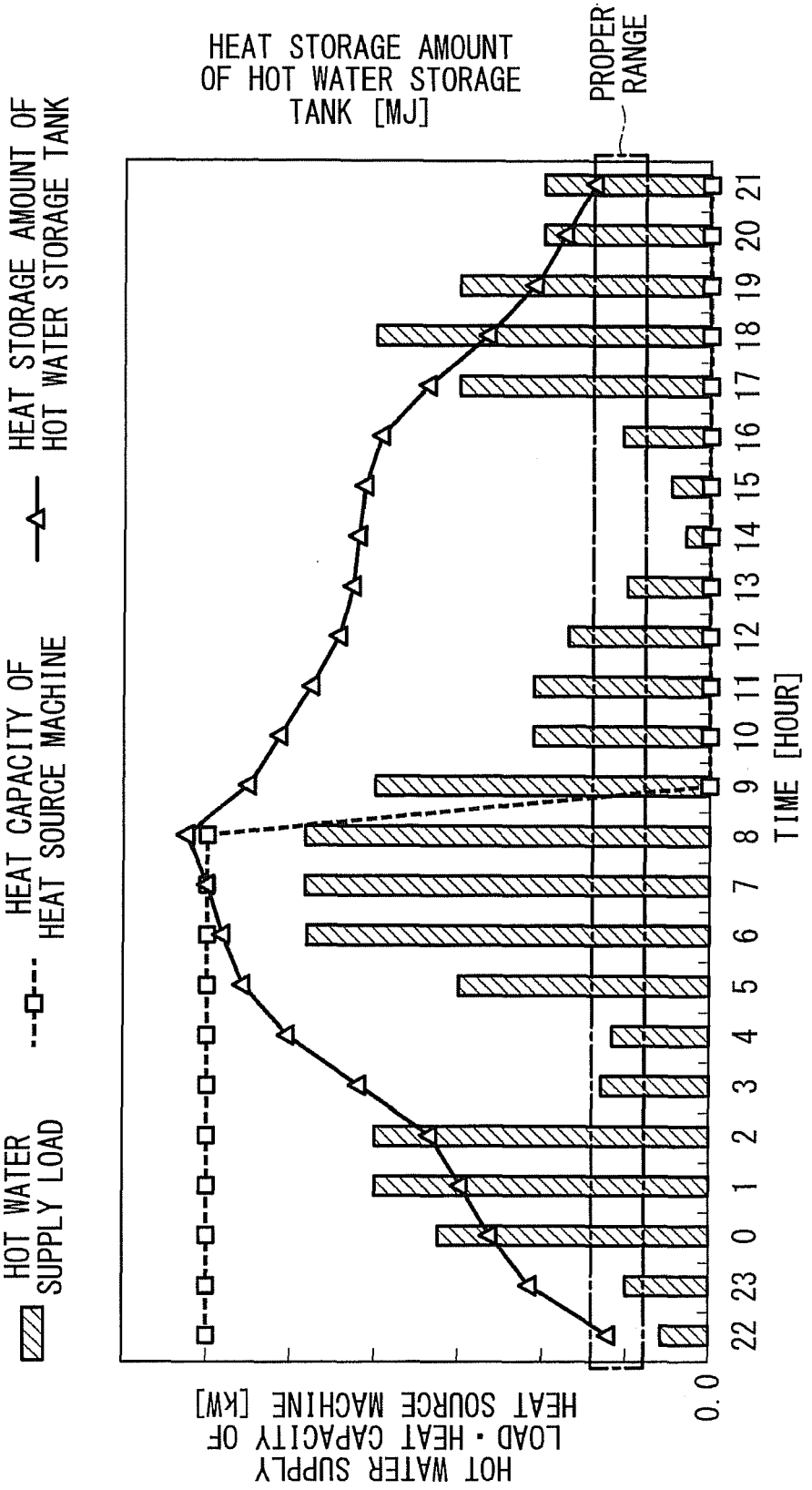
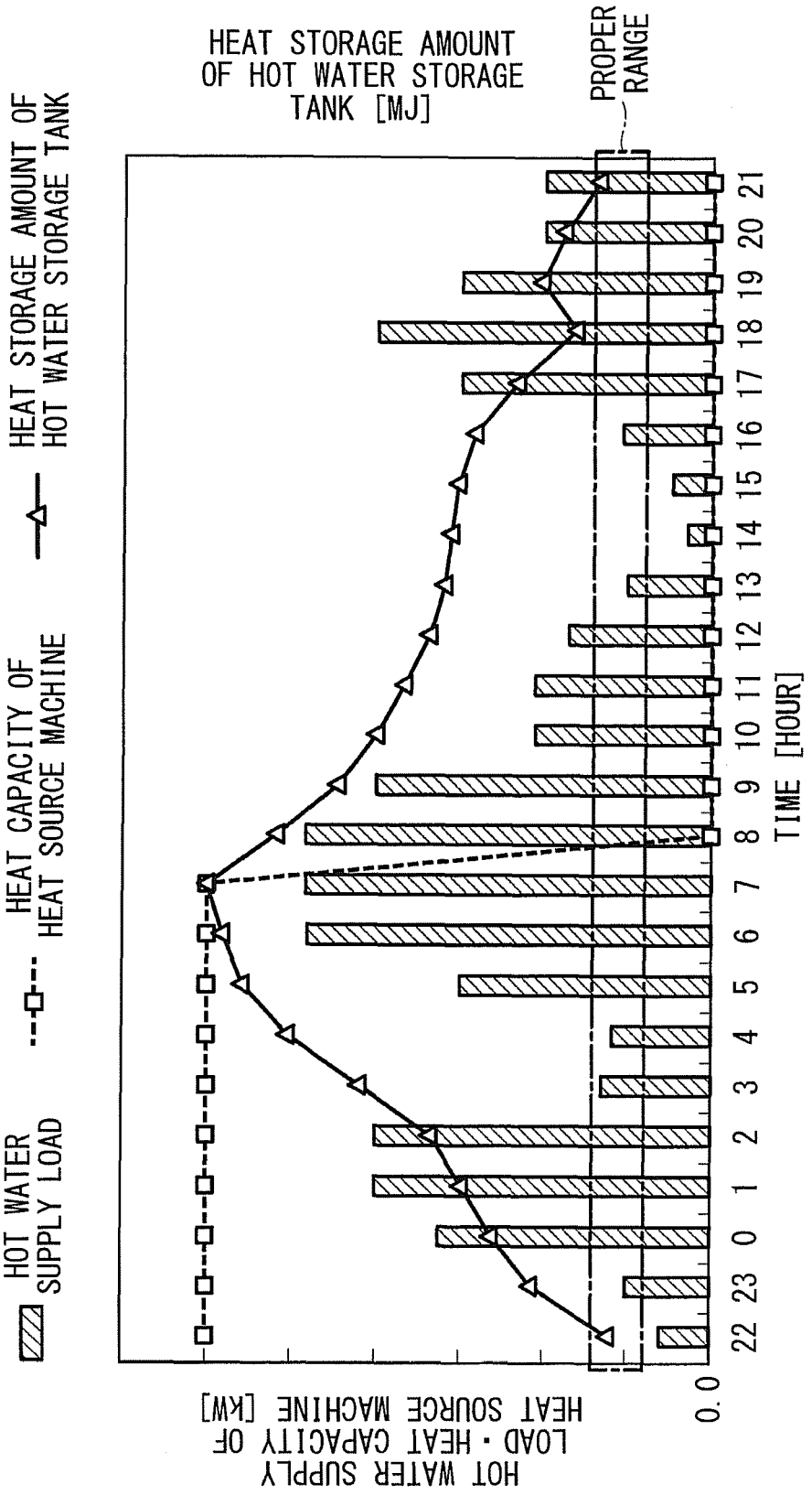

HOT WATER SUPPLY LOAD
HEAT CAPACITY OF HEAT SOURCE MACHINE
HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK
HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK [MJ]
PROPER RANGE
HOT WATER SUPPLY LOAD · HEAT CAPACITY OF HEAT SOURCE MACHINE [kW]
0.0
22 23 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
TIME [HOUR]

FIG. 14


HOT WATER SUPPLY LOAD
HEAT CAPACITY OF HEAT SOURCE MACHINE
HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK
HOT WATER SUPPLY LOAD · HEAT CAPACITY OF HEAT SOURCE MACHINE [kW]
HEAT STORAGE AMOUNT OF HOT WATER STORAGE TANK [MJ]
PROPER RANGE
0.0
22 23 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
TIME [HOUR]

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EUROPEAN SEARCH REPORT

Application Number
EP 15 15 6717

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 261 574 A1 (HITACHI APPLIANCES INC [JP]) 15 December 2010 (2010-12-15) * paragraphs [0001] - [0006] *	1-6	INV. F24D19/10 F24H1/18 F24D17/00
A	EP 2 484 987 A1 (PANASONIC CORP [JP]) 8 August 2012 (2012-08-08) * paragraphs [0001] - [0012] *	1-6	
A	JP 2012 032117 A (PANASONIC ELEC WORKS CO LTD) 16 February 2012 (2012-02-16) * paragraphs [0001] - [0007]; figures 1-2 *	1-6	
A	JP 2007 187382 A (DENSO CORP) 26 July 2007 (2007-07-26) * abstract * * figure 1 *	1-6	
A	US 2013/284818 A1 (HAYASHIDA GAKU [JP] ET AL) 31 October 2013 (2013-10-31) * paragraphs [0040] - [0045] *	1-6	

TECHNICAL FIELDS SEARCHED (IPC)
F24D
F24H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 July 2015	Polednicek, Milos

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23-07-2015

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		WO 2013027312 A1	28-02-2013

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